A STUDY PLAN TO INVENTORY
BIOTIC RESOURCES AT THE
SAN FRANCISCO BAY AREA NATIONAL PARKS

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Table of Contents

SECTION I: INTRODUCTION

In 1992, the National Park Service's (NPS) Inventory and Monitoring Program identified a list of candidate elements and processes for initial inventory in all natural resource parks, proposed the establishment of prototype inventory and monitoring parks, and outlined national implementation guidelines. The NPS Servicewide I&M Program also recommended that it be NPS policy to "assemble baseline data.... and to monitor those resources forever -- to detect or predict changes that may require intervention, and to serve as reference points for more altered parts of the environment"(NPS-75: Natural Resources Inventory and Monitoring Guideline). In 1999, the Natural Resource Challenge (NRC) Initiative re-energized the Inventory and Monitoring Program. Strategic objectives of the NRC initiative stressed the need for an inventory of what resources exist and in what conditions in order to fulfill the NPS natural resource stewardship goal.

Species inventories are of paramount importance for all national parks with natural resources. Inventories are important on several levels including scientific, interpretive and management. These inventories enable interpreters to share useful information with the visiting public to enhance their appreciation of natural resources. Additionally, knowledge from inventories can guide park staff in making management decisions based on sound scientific data. Finally, inventories provide the scientific community with new information on the occurrence and distribution of species and provide reference information for long-term monitoring programs.

The purpose of this study is to complete basic biological inventories in parks of the San Francisco Bay Area Network (SFBAN) of central California. The SFBAN includes Eugene O'Neill National Historic Park (EUON), Fort Point National Historic Site (FOPO), Golden Gate National Recreation Area (GOGA), John Muir National Historic Site (JOMU), Muir Woods National Monument (MUWO), Pinnacles National Monument (PINN), Point Reyes National Seashore (PORE), and the Presidio (PRES). All eight parks occur within 150 miles of each other and several of the parks border each other. All together the parks comprise over 159,000 acres of land, 25,000 acres of marine waters, and nearly 100 linear miles of shoreline (Figure 1). Although separate units of the National Park Service, FOPO and PRES are administered by GOGA and therefore included under GOGA for the purposes of this study plan.

The eight parks that comprise the SFBAN propose to complete steps necessary for conducting biological inventories of vertebrate fauna, vascular plants, and select invertebrate fauna and non-vascular plants in the aquatic ecosystems as presented in the "Guidelines for Biological Inventories" distributed by the NPS Inventory and Monitoring Program.

Five of the parks (GOGA, MUWO, PRES, FOPO, PORE) conducted an Inventory and Monitoring scoping workshop in 1997 in preparation for conducting inventories and for developing a vital signs monitoring program. During the scoping workshop, the parks 1) defined the primary objectives of a long-term monitoring program,
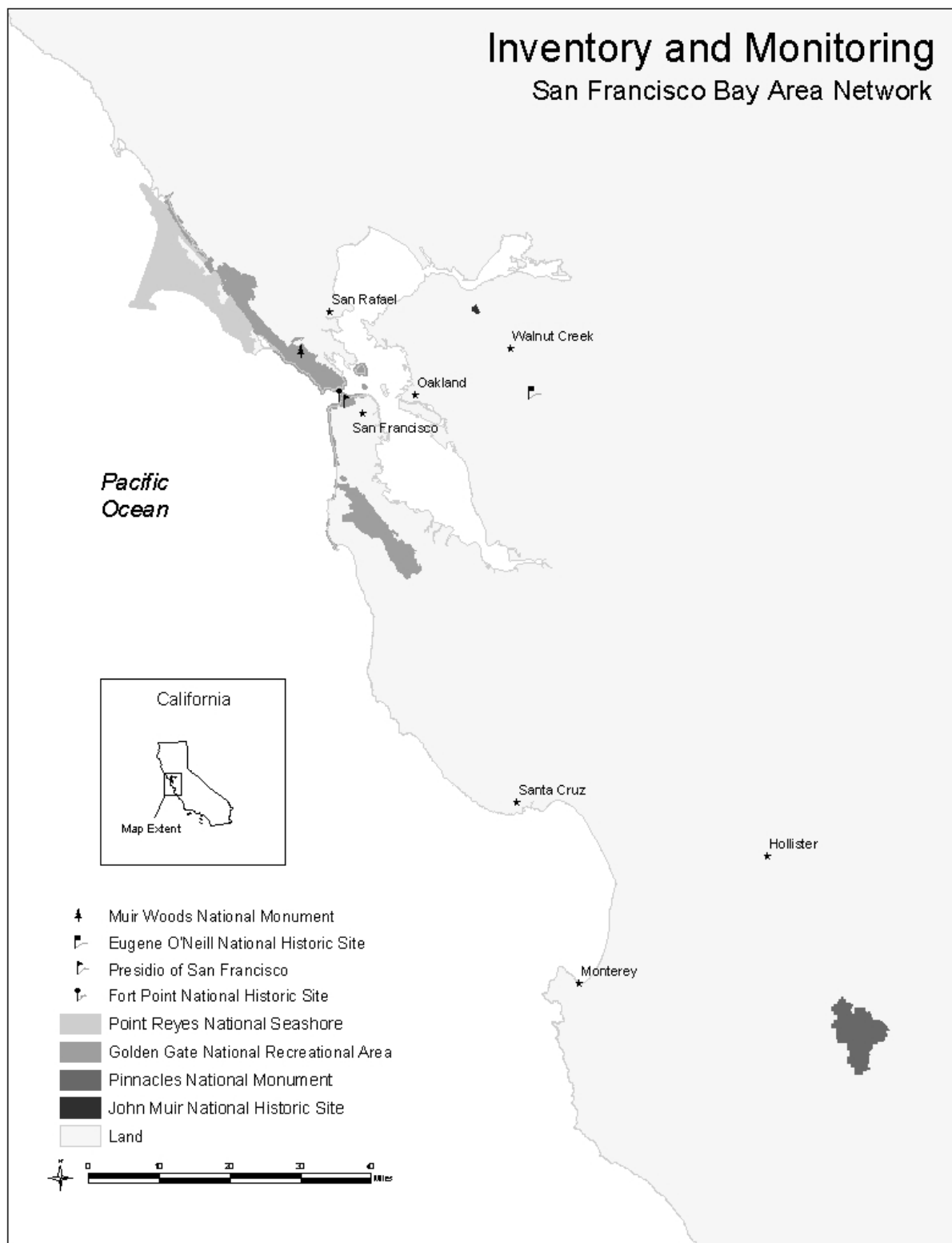
Figure 1. The San Francisco Bay Area Network Parks.

2) developed a conceptual model of the parks' ecosystems, 3) identified what had and had not been inventoried, 4) identified park threats/stressors and 5) selected components for monitoring. The other three parks (EUON, PINN and JOMU) have been incorporated into this program in order to develop this Network Biological Inventory Plan, which will be a driving force in the future development of a biological monitoring plan for the SFBAN. An additional scoping session to address the needs, goals, and objectives of monitoring programs within the SFBAN will be scheduled in 2001.

Biological Inventory Plan Objectives

Specific objectives of this Biological Inventory Plan are to:

1. Present a compilation and synthesis of existing and historical data for all species of vascular plants and vertebrates in the SFBAN parks.

2. Identify information gaps and propose a strategy to complete field inventories of a prioritized list of biotic resources in the SFBAN parks, ensuring that 90% of species likely to exist in the parks are documented and vouchered.

3. Propose a strategy to inventory species of special interest and develop spatial distribution maps and estimates of abundance or condition. Species of interest are based on whether a species is federally or state listed, or is a species of special concern due to rarity or management considerations.

Relationship to Government Performance and Results Act (GPRA)

The Biological Inventory Plan for the SFBAN is a significant and specific step towards fulfilling GPRA Goal Category I (Preserve Park Resources) for this network. The servicewide goal of Natural Resource Inventories (Ib1) specifically identifies the strategic objective of inventorying the resources of the parks as an initial step in protecting and preserving park resources. This goal tracks the amount of basic natural resources information that is available to parks and performance is measured by what datasets are obtained. The service-wide long-term goal is to "acquire or develop 87% of the outstanding datasets identified in 1999 of basic natural resource inventories for all parks". The Biological Inventory Plan will delineate what information exists and in what format/condition, and will identify what information is missing and requires further study.

BACKGROUND

Significance of Resources

The National Parks of central California are recognized as biologically significant on several levels and form part of a large safety net for resource protection and management in central California. The parks are bordered by three National Marine Sanctuaries (Gulf of the Farallones, Monterey Bay, and Cordell Banks), an International Man and the Biosphere Reserve, two National Wildlife Refuges, several state Areas of Special Biological Significance, and several state parks and reserves.

The SFBAN represents one of the 6 most significant areas in the nation for biodiversity as identified by the Nature Conservancy (Figure 2, The Nature Conservancy, 2000). Nationally, the parks are significant to the National Park System for: 1) supporting many endemic species and communities despite close proximity to the large urban zone of the San Francisco Bay region, 2) preserving biologically and geologically diverse habitats and their associated species, and thereby 3) providing opportunities for recreation, education and aesthetic enjoyment to a large urban population.
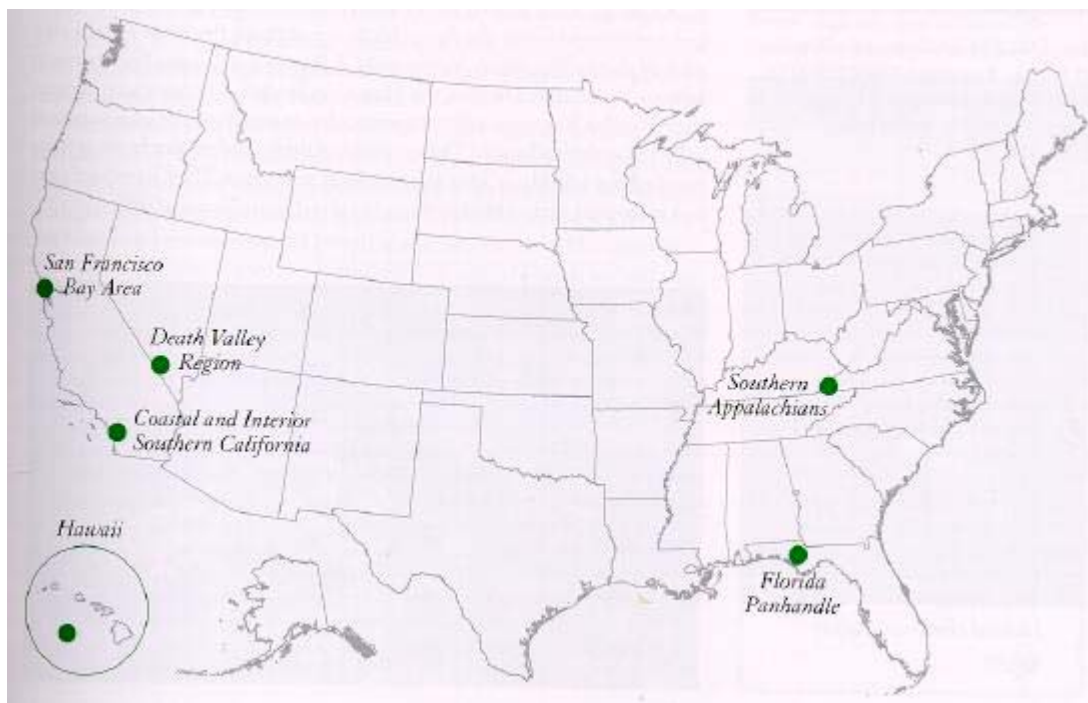
Figure 2. The San Francisco Bay Area Network of parks is one of the top 6 significant areas in the nation for biodiversity (The Nature Conservancy, 2000).
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Internationally, the SFBAN of parks falls within the 8th most significant "hot spot" in the world for biodiversity and at great risk due to rapid human population growth (Figure 3, Cincotta and Engelman, 2000). With a current population of 6.9 million and three metropolitan centers, San Francisco, Oakland, and San Jose, the San Francisco Bay Area is forecast to have a population of 8 million by 2020 (Association of Bay Area Governments, 2000). Recognizing the extraordinary significance and exposure to threats in the region, the UNESCO Man in the Biosphere program designated the Central California International Biosphere Reserve in 1988, encompassing PORE, GOGA, MUWO, PRES, and FOPO.

These attributes of diversity, complexity, rarity and proximity make balancing the National Park Service mandates of use and preservation more difficult and urgent.
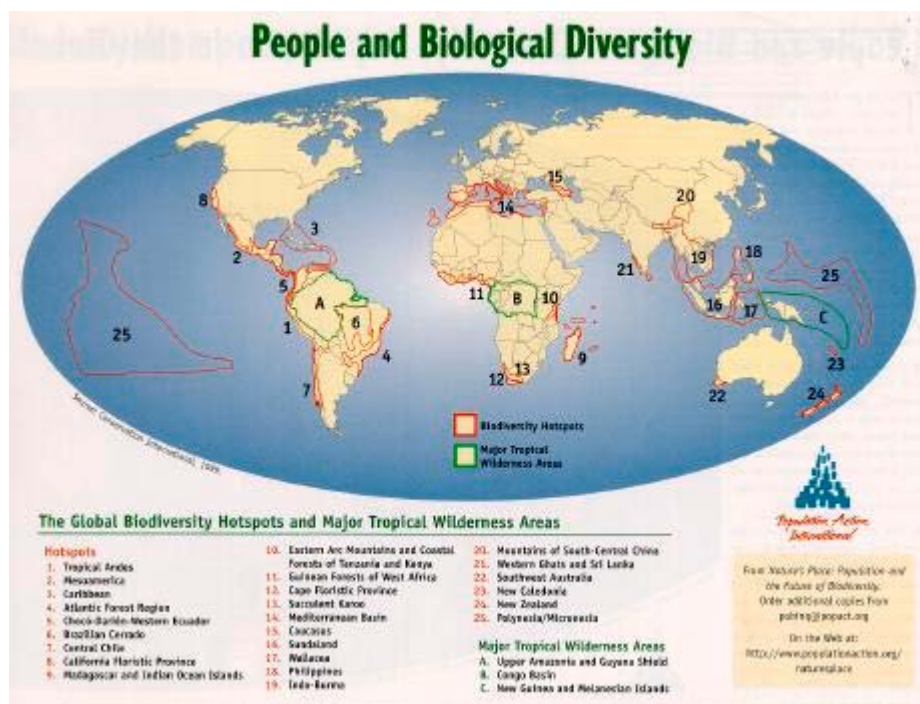
Figure 3. The San Francisco Bay Area Network of parks is located in the 8th most significant hot spot in the world (Cincotta and Engelman, 2000).

Resource Values

The abundance and diversity of the ecosystems, and their components, of the central California SFBAN are remarkable. The parks are located within three ecological sections: 1) the Central Californian Coast (natural communities include the coast live oak, chamise, valley oak, redwood, Douglas-fir – tanoak, chaparral, and grassland series), 2) the Northern California Coast (natural communities include the redwood, Douglas-fir – tanoak, coast live oak, chaparral, and grassland series), and 3) the Central California Coast Ranges (natural communities include the coast live oak, chamise, valley oak, and mixed chaparral series) (Bailey, 1994; Bailey *et al.*, 1994). In addition, the varied geology (including significant geologic features and earthquake faultlines) creates many soil types on which a variety of plants have adapted.

The topographical relief of the parks ranges from sea level to 3300 feet above mean sea level. Hillslopes range from almost flat marine terraces and alluvial deposits to steep canyons along some creeks. The San Andreas Fault, the dominant geologic force for the region, is the meeting of the Pacific and Continental Plates. As the Pacific Plate migrates northwestward, it has created and continues to create the fractured landscape with unique geology and soil types. Starting in southern California and extending into the Pacific Ocean through Tomales Bay (PORE/GOGA), the San Andreas Fault is responsible for making PORE a distinct landscape adjacent to the mainland geology of

GOGA with marked differences in geomorphology, soils and plant communities. While a volcano created the rock formations of PINN, it is the San Andreas fault and its associated fault zone that upthrusted these rock spires to the skyline.

Located at the convergence of a number of ocean currents, the marine environment is equally complex and expansive. The marine waters under the jurisdiction of PORE and GOGA are rich in nutrients and support an abundant and diverse fauna. A regional plume of upwelled water, with concentration at the Point Reyes Headlands, is one of only five coastal upwelling ecosystems in the world and the only one in North America. The nutrient-rich, upwelled water provides the basis for a distinct, productive food web. The San Francisco Bay plume of freshwater extends through the Golden Gate and out into the Gulf of the Farallones. Although also rich in nutrients, the San Francisco Bay plume is warmer and less saline than the upwelled waters.

These and other physical and biological factors have led to a wide diversity of plants and animals, both in the marine and terrestrial realms of the SFBAN. Just in the marine ecosystem alone, more than a third of the world's cetacean species occur off San Francisco Bay and Point Reyes. Additionally, PORE and GOGA contain a number of significant haul-out and pupping areas for pinnipeds, representing 20% of the state population of harbor seals, and one of only 4 mainland breeding areas worldwide for northern elephant seals (Sydeman and Allen, 1999; Allen et.al.1989). The terrestrial landscapes are equally significant, diverse and rare, representing a high degree of endemism. They include such diverse vegetation alliances as active coastal fore dunes, coastal terrace prairie, serpentine chaparral, serpentine bunchgrass, northern coastal salt marsh, coast live oak woodland, valley oak woodland, and ancient redwood forests. Nearly sixty federal or state listed threatened and endangered species occur within the SFBAN as residents or seasonal migrants (Table 1).

PARK DESCRIPTIONS

Eugene O'Neill National Historic Site was established in 1976 to honor the only Nobel Prize winning playwright from the United States and the architect of modern American theater. O'Neill lived at this site in the hills above Danville from 1937 to 1944 in Tao House. It was here that he wrote his final and most successful plays; "The Iceman Cometh," "Long Days Journey Into Night," and "A Moon For the Misbegotten." Since 1980, the NPS has been restoring Tao House, its courtyard and orchards and telling the story of O'Neill, his work and his influence on American theater. EUON encompasses 13 acres of historical buildings, gardens and orchards, and is adjacent to several hundred acres of protected lands of the Briones State Park.

Fort Point National Historic Site is managed by Golden Gate National Recreation Area. Fort Point National Historic Site, designated as a National Historic Site in 1970, consists of 29 acres bordering the mouth of San Francisco Bay at the south side of the Golden Gate. The U.S. Army Corps of Engineers constructed Fort Point

Table 1. Federal and/or state threatened and endangered species known to occur within the SFBAN parks.

Common Name	Federal	State	Park
Invertebrates			
California Freshwater Shrimp	FE	SE	GOGA, PORE
Mission Blue Butterfly	FE		GOGA
San Bruno Elfin Butterfly	FE		GOGA
Bay Checkerspot Butterfly	FT		GOGA
Myrtle's Silverspot	FE		PORE
Fishes			
Coho Salmon- Central CA Coast ESU	FT		GOGA, PORE, MUWO
Chinook Salmon- Sacramento River winter run	FE	SE	GOGA
Chinook Salmon – Central Valley spring run	FT		GOGA
Steelhead- Central CA Coast ESU	FT		GOGA, PORE, MUWO
Steelhead- Central Valley ESU	FT		GOGA
Tidewater Goby	FE	CSC	GOGA, PORE
Amphibians			
California Red-legged Frog	FT	CSC	GOGA, PINN, PORE, MUWO
Reptiles			
Loggerhead Sea turtle	FT		GOGA, PORE
Green Sea Turtle	FT		GOGA, PORE
Leatherback Sea Turtle	FE		GOGA, PORE
San Francisco Garter Snake	FE	SE	GOGA
Birds			
California Brown Pelican	FE	SE	GOGA, PORE
Bald Eagle	FT	SE	GOGA, PORE
American Peregrine Falcon	FD	SE	GOGA, PINN, PORE
California Condor	FE	SE	PINN
Western Snowy Plover	FT	CSC	GOGA, PORE
California Least Tern	FE	SE	GOGA, PORE
Marbled Murrelet	FT	SE	GOGA, PORE
Northern Spotted Owl	FT		GOGA, PORE, MUWO
Aleutian Canada Goose	FT		PORE
Greater Sandhill Crane		ST	GOGA, PORE
California Black Rail	(FSC)	ST	GOGA, PORE
California Clapper Rail	FE	SE	GOGA, PORE
Bank Swallow		ST	GOGA, PORE
Swainson's Hawk		ST	GOGA, PORE
Willow Flycatcher		SE	GOGA, PORE
Mammals			
Salt Marsh Harvest Mouse	FE	SE	GOGA
Steller (Northern) Sea Lion	FT		GOGA, PORE
Guadalupe Fur Seal	FT	ST	PORE
Southern Sea Otter	FT		GOGA, PORE
Blue whale	FE		GOGA, PORE
Humpback Whale	FE		GOGA, PORE
California Gray Whale	FD		GOGA, PORE
Plants			
San Mateo Thorn-mint	FE	SE	GOGA
Sonoma Alopecurus	FE		PORE
Presidio Manzanita	FE	SE	GOGA
Point Reyes Blennosperma	(FSC)	SR	PORE
Mason's Ceanothus	(FSC)	SR	GOGA
Sonoma Spineflower	FE	SE	PORE
Fountain Thistle	FE	SE	GOGA
Presidio Clarkia	FE	SE	GOGA
San Mateo Woolly Sunflower	FE	SE	GOGA
Marin Dwarf Flax	FT	ST	GOGA
Beach Layia	FE	SE	PORE
San Francisco Lessingia	FE	SE	GOGA
Point Reyes Meadowfoam	(FSC)	SE	PORE
Tidestrom's Lupine	FE	SE	PORE
Santa Cruz Island Bush Mallow	FE	SE	GOGA
White-Ray Pentachaeta	FE	SE	GOGA, PINN
San Francisco Popcorn-flower	(FSC)	SE	PORE

Federal and State Listing Status:

FE = Federally Endangered	SE = State Endangered	(FSC) = Federal Species of Concern– former Category 2 candidates (no
FT = Federally Threatened	ST = State Threatened	longer an active, legal term)
FD = Federally De-listed	SR = State Rare	CSC = California Species of Special Concern (CDFG 2000)

between 1853 and 1861 to prevent entrance of a hostile fleet into San Francisco Bay. The Fort was occupied throughout the Civil War. Today the site receives over 1.5 million visitors a year. Fort Point is particularly noteworthy for several rare and endemic plant species. Native plant communities still cling to the precipitous slopes above the Fort. Freshwater seeps at Fort Point support the rare San Francisco fork-tailed damselfly. The site also includes the waters of San Francisco Bay within ¼ mile of shore, which serve as important wintering sites for thousands of terns, loons, grebes and cormorants. Recreational fishing and crabbing are popular resource dependent activities at Fort Point

Golden Gate National Recreation Area comprises approximately 75,000 acres of coastal lands in the San Francisco Bay Area including the mouth of San Francisco Bay, one of the largest ports in the United States. GOGA was established in 1972 as part of the "parks to people" program, and the enabling legislation stated that the lands were founded "in order to preserve for public use and enjoyment certain areas …possessing outstanding natural, historic, scenic and recreational values…". This long, narrow park is divided by the Golden Gate entrance to the San Francisco Bay, which separates the northern Marin County lands from the southern San Francisco and San Mateo County lands. The legislative boundary encompasses the Marin Headlands north of and ocean shoreline south of the Golden Gate, Alcatraz Island, and all of the coastal watersheds south and east of Point Reyes National Seashore, including Mt. Tamalpais, Samuel P. Taylor, Angel Island, and Tomales Bay State Parks. In addition, the park has a scenic and recreational easement over the 20,000 acre San Francisco Watershed lands. The Presidio of San Francisco is also within the park. GOGA leases submerged and tidal lands along the open coast and within the San Francisco Bay from the State of California. GOGA is bordered by two National Marine Sanctuaries and is part of the Central California International Biosphere Reserve (UNESCO Program).

The complex geology, topography and microclimatology of GOGA support a diverse array of native habitats. The degree of threat to these resources is a result of the park's juxtaposition within the urban landscape and the extensive urban / wildland interface within the park. Invasive species, plant and animal, terrestrial and aquatic, are one of the most significant threat to the long-term sustainability of the park's native ecosystems. Limiting the impacts of intense human use of the park is a constant challenge.

John Muir National Historic Site was set aside in August 1964 as a national memorial to the preservationist, John Muir. Located in Martinez, JOMU is part of the rapidly expanding urban, suburban industrial San Francisco Bay Area complex. JOMU encompasses 345 acres, only 8.9 acres of which include the house area and the adjacent ranch where John Muir made his home. The Muir House area includes historic buildings and trees, orchards, a vineyard, and the park visitor center. JOMU recently acquired Muir's gravesite (1.3 acres), which encompasses nine family graves surrounded by a historic pear orchard. The adjacent Mt. Wanda area (326 acres) is included within the boundaries of the park and is characterized by grassland and oak woodland vegetation. It also contains remnants of a historic fruit orchard and an ephemeral stream that drains into Alhambra Creek.

Resource management concerns at JOMU include the effects of long-term fire suppression, accelerated erosion in disturbed areas, lack of fire ecology research and a comprehensive fire management program, lack of information on visitor use impacts, non-native species invasions, and lack of basic ecological data for the management and monitoring of natural resources. There have been incidental surveys within the site for birds and plants, but a formal, systematic inventory has not been conducted.

Muir Woods National Monument was established in 1908 by this proclamation: "An extensive growth of redwood trees (*Sequoia sempervirens*) embraced in said land is of extraordinary scientific interest and importance because of the primeval character of the forest in which it is located, and the character, age and size of the trees, are hereby preserved from appropriation and use of all kinds under public land laws of the United States and set apart as a national monument, to be known and recognized as the Muir Woods National Monument."

The monument, located in Marin County only 17 miles north of San Francisco, encompasses only 554 acres but receives nearly 900,000 visitors a year. MUWO is managed by the Golden Gate National Recreation Area. The dominant vegetation of MUWO is old-growth redwood growing in uneven-aged stands with trees ranging up to 800 years old, within a mosaic of redwood, Douglas-fir, hardwood, scrub and grassland. The largest trees within MUWO grow within the flood plain of Redwood Creek. This fragment of old-growth habitat harbors four federally listed threatened species, including coho salmon, steelhead trout, California red-legged frog and the northern spotted owl. Other rare or sensitive species within MUWO include monarch butterflies, California bottlebrush grass and several species of bats.

The Redwood Creek hydrologic system within MUWO has been disturbed by past activities and developments including parking lots, stream bank protection, in-stream grading, and removal of woody debris from the streambed, water withdrawals, agriculture, logging (outside of MUWO), as well as intense recreational use. These activities and developments have altered the stream course, the amount of overland flow and/or the quantity and quality of aquatic habitat. Habitat quality downstream of MUWO directly affects the threatened and endangered species present within MUWO. Redwood Creek watershed and MUWO are currently the focus of a variety of activities including watershed planning, transportation planning, Visitor Experience and Resource Protection study, water quality and water rights investigations, sensitive wildlife species inventory, sensitive species monitoring, aquatic system and riparian restoration, invasive non-native plant removal and habitat restoration, and GIS mapping of all watershed features. Inventory and monitoring data are critical inputs to all planning efforts and the long-term sustainability of this isolated fragment of old-growth redwood habitat.

Pinnacles National Monument occupies 24,000 acres in Monterey and San Benito Counties, 40 miles inland from the Pacific Ocean in central California. PINN was decreed a National Monument in 1908 to protect its unique assortment of rocks, cliffs, and caves formed by ancient volcanic activity. In January 2000, President Bill Clinton, acting under the Antiquities Act passed by Congress in 1906, proclaimed expansion of PINN by nearly 8,000 acres,

increasing the size of the park by 50%. The adjacent public lands have been transferred from the Bureau of Land Management to the NPS. Approximately 75% of PINN is Congressionally designated wilderness with an additional 10% designated as potential wilderness. As the human populations in California continue to grow and move toward PINN, these wilderness areas will increase in importance.

Nearly six million people live within a 100-mile radius of PINN and about 20 million within a 200-mile radius, making it easily accessible to people living in the major California metropolitan centers of Los Angeles and the San Francisco Bay Area. The cool temperatures, moist conditions, abundant wildflowers and flowing streams attract a large percentage of PINN's visitors in the winter and spring months. Although the immediate area is sparsely populated, PINN has rapidly fallen under the influence of an expanding adjacent urban concentration, making tourism a primary component of the local economy.

PINN lies at the southern end of the Gabilan Mountains, which are early Paleozoic in age (around 510 million years old) and consist primarily of granite, gneiss, schist and marble. The topography of PINN ranges from rolling hills to rock spires, crags and other points of sharp relief. Elevations in the monument range from less than 1,000 feet along South Chalone Creek to 3,304 feet at the summit of North Chalone Peak.

Pinnacles is a refuge for many species associated with coastal California communities. Species richness is high with many representatives of the same genera present in small but unbroken ecosystems. Recent investigations have recorded 410 different bee species and a strong migrant, bird population using PINN in the early spring. The broadleaf chaparral ecoregion supports abundant populations of vegetation and wildlife, representing a high degree of biodiversity. Years of fire suppression and adjacent land management practices have altered the wildlife habitat making it difficult to sustain populations of large predators such as bears, mountain lions, and coyotes. The expansion of PINN's boundary has included habitat types that were not represented in the core area of the park and will greatly enhance populations that have large home range sizes.

Point Reyes National Seashore, located in Marin County, California, is approximately 40 miles northwest of San Francisco. Established by Congress in 1962, this geologically unique peninsula encompasses 71,046 acres of sandy beaches, coastal cliffs and seastacks, marine terraces, coastal uplands of mixed grassland, coastal scrub, mixed hardwood/Douglas-fir forests, and stands of the rare Bishop pine, and 22,000 acres of estuarine and marine waters. Migrating northward along the San Andreas Fault, the Seashore has appropriately been called an "Island in Time."

Approximately 19,000 acres of Point Reyes National Seashore have been retained in agricultural production within a "pastoral zone." Within this zone, six active dairies graze a total of 7,700 acres. An additional 11,200 acres are in beef cattle grazing. The Northern District of GOGA, which is administered by PORE, contains an additional 10,500 acres that are in beef cattle grazing.

In 1976, Congress designated 32,000 acres of PORE as wilderness. Located near the San Francisco metropolitan area, this area is one of the most accessible within the United States wilderness system.

The marine environment, influenced by the rugged topography of the peninsula, drives the climate of Point Reyes and significantly adds to the abundance and diversity of wildlife. Point Reyes is the center of one of only five coastal upwelling marine ecosystems in the world. Located at the convergence of a number of ocean currents, adjacent waters are rich in nutrients and support an abundant fishery and associated fauna. Several marine areas along the Point Reyes coastline have been recognized for their biological significance and receive some protection. The Point Reyes Headlands Reserve and Estero de Limantour Reserve are within the Seashore boundary and are administered by the California Department of Fish and Game (CDFG). Additionally, the California State Water Resources Control Board designated four "Areas of Special Biological Significance" within the Seashore: Tomales Point, Point Reyes Headlands, Double Point, and Duxbury Reef. Similar to GOGA, PORE is bordered by two National Marine Sanctuaries and is part of the Central California International Biosphere Reserve (UNESCO Program).

PORE supports a unique and varied landscape that has been subject to a broad range of human and natural events. As with GOGA, invasive species, plant and animal, terrestrial and aquatic, are one of the most significant threats to the long-term sustainability of the park's native ecosystems. Saved from development by its inclusion within the National Park Service System, Point Reyes is unique not only in its assemblage of natural and cultural features, but also in its proximity to a major urban population. This juxtaposition makes the Seashore's resources and recreational opportunities readily accessible to a large number of people.

The Presidio of San Francisco was designated a National Historic Landmark District in 1962 and became part of GOGA in 1994. Since 1998 the Presidio of San Francisco has been jointly managed by the National Park Service and The Presidio Trust, a special public-private governmental agency tasked with managing most of the buildings of the Presidio and making the park financially self-sufficient by 2013. The Presidio encompasses 1,480 acres, more than 500 historic buildings, a collection of coastal defense fortifications, a national cemetery, an historic airfield, 300 acres of historic forests, beaches, native plant habitats, coastal bluffs and newly restored Crissy Field tidal wetland and coastal dunes. Eleven rare or endangered plant species inhabit the dune and serpentine areas of the Presidio. Many of these species' distributions are extremely limited or occur only on the Presidio.   Over 200 species of birds, including 50 nesting species, have been documented on the Presidio. The extent of native habitat and diversity of native plants, birds, fish and invertebrates is increasing dramatically with community-based efforts to restore tidal wetlands, a freshwater lake, riparian habitat, coastal dunes and serpentine bluff habitat throughout the Presidio. Invasive non-native plants, non-native aquatic plants, fish and invertebrates, and unnaturally elevated populations of native wildlife (e.g. skunks and raccoons) pose a significant threat to Presidio natural resources. Intense human use of the Presidio also takes its toll on the Presidio's fragile natural resources.

SECTION II: SIGNIFICANT INVENTORY WORK IN PROGRESS

Overview

Several inventory projects currently in progress within the SFBAN have received support from the first year of I&M funding for this Network (see Section V: Budget and Schedule). These and other projects presented below influenced the development of this study plan and had significant bearing on the allocation of available I&M funds.

Herbarium Assessment

The herbariums at PORE, GOGA, and PINN are valuable resources that require management to keep the collections current and in good condition. Although EUON and JOMU do not currently support plant collections, vegetation occurring at these parks also must be documented and vouchered.

 This herbarium project was undertaken to achieve the following objectives:

1)   to asses the condition of existing plant collections in all network units;
2)   to identify herbarium needs (including additional plant collections, specimen identification, hardware, and supplies); and
3)   to acquire hardware components and supplies necessary to maintain the collections in good condition.

In May 2000, a contract was established between the National Park Service and KEA Environmental, Inc. to have KEA botanists assist with this project. Park contacts on this contract are Barbara Moritsch (PORE), Sharon Farrell (GOGA), and Tom Leatherman (PINN).

Initially, work was to be performed on herbaria at PORE and GOGA only. However, several tasks to be completed for the PINN herbarium collection were added to the contractor's scope of work at the request of PINN's botanist.

The scope of work for this project includes the following tasks:
- cross check the current vascular plant species lists from PORE, GOGA, and PINN with their herbarium collections to identify gaps in the herbarium collections;
- determine herbarium/plant documentation needs for EUON and JOMU;
- determine condition of existing vascular plant specimens;
- determine utility of unaccessioned or unmounted specimens (e.g., if collection location cannot be determined, specimens may be discarded);
- attempt to complete missing information on specimens with incomplete records (e.g., contact collector, identify specimens, locate expert who can identify specimens)
- determine the most effective specimen storage system and help acquire components for this system;

- contact California Academy of Sciences Herbarium, Jepson Herbarium and other local herbaria to request species lists of collections from PORE, GOGA, EUON, JOMU and PINN housed in their facilities;

- search NPS databases of research and collection permits to determine which permittees collected plant materials, and if time permits, contact researchers to determine what material was collected and where it was sent;

- supplement collections with additional specimens and mount and accession any new specimens; and

- present findings to the network Inventory Coordinator in order to update NPSpecies, NRBib, and ANCS+ databases.

As of 30 August, 2000 work had begun on the herbarium at PORE. The existing collection has been assessed. All materials stored in the herbarium cabinets have been examined and compared to the current herbarium inventory list. The mounted specimens are in good condition and do not require remounting or replacement. Unmounted specimens of both vascular (approximately 75) and nonvascular plants (marine algae and miscellaneous unidentified fungi) are in poor condition and may not be useable. The PORE plant species list presently is being compared with the herbarium collection to determine additional collection needs. The contractor is coordinating with PINN and GOGA staff to set up site visits.

Land-Cover Mapping for PORE and GOGA

A draft vegetation map for approximately 155,000 acres, encompassing PORE, GOGA (including MUWO, FOPO, PRES, and the San Francisco Watershed), Angel Island State Park, Samuel P. Taylor State Park, Mount Tamalpais State Park, and Tomales Bay State Park was completed under an existing USGS-NPS contract with Environmental Systems Research Institute, Inc. (ESRI). Funding for this project was received through the I&M Program, FirePro, PORE, GOGA, the California State Department of Parks and Recreation, the Gulf of the Farallones National Marine Sanctuary, and regional NPS GIS funds. A subcontractor to ESRI, Aerial Information Systems, Inc. (AIS) conducted the aerial photo interpretation. This aerial photo based GIS map is at a scale of 1:24,000, with a minimum mapping unit of 0.5 hectares. Approximately 15,000 land-cover polygons representing 73 different cover types were delineated.

At the initiation of the project, the NPS provided ESRI with aerial photographs of the project area (in the form of natural color diapositives at a scale of 1:24,000). Preliminary photo interpretation was done prior to a field reconnaissance. Photo interpreters from the ESRI/AIS team then visited the project area to determine the signatures associated with dominant vegetation types.

Photo interpretation was done to the alliance level for all vegetated polygons delineated on the aerial photos. Whenever discernible, interpreters assigned a vegetation association to the polygons.

When photo interpretation was completed, the mapping team conducted a second field visit to resolve questions about specific problem areas identified during interpretation. These areas primarily included grassland and coyote brush scrub (*Baccharis pilularis*) vegetation types. The draft maps and data were edited to reflect the field review.

During the growing seasons of 1999 and 2000, several NPS field crews collected vegetation data to assess the accuracy of the draft map. Approximately 1,600 polygons were selected for accuracy assessment based on the standards described in the USGS/NPS land-cover mapping guidelines (http://biology.usgs.gov/npsveg/). The majority of the accuracy assessment polygons chosen were within 300 meters of roads and trails in order to increase sampling efficiency. Due to budgetary constraints, field crews will only be able to visit about 1,200 of these points. Existing vegetation data from the Point Reyes Bird Observatory and the USGS Golden Gate Field Station are being used to increase the sample size of accuracy assessment points.

A representative point within each accuracy assessment polygon was selected using draft vegetation polygons and Digital Orthophoto Quads (DOQs) by heads up digitizing. Then field crews navigated to these points using GPS. Crews keyed out the plant community to alliance and association when possible and collected data on plant composition and what other vegetative communities occur within the polygon. In cases where wetland types were encountered, detailed wetland information was collected.

Vegetation Classification

Concurrent with development of the map, NPS resource management staff collected data to develop a classification system and key for identifying the vegetation types within the project area. The NPS field crews collected detailed vegetation data from 360 plots. Data collection and development of the classification system were done in conformance with USGS/NPS standards and protocols. The photo interpreters, to help them identify the characteristic signatures of the vegetative communities, also used these data.

Vegetation data for the classification were taken from a sample of polygons representing each of the vegetation types identified during initial aerial photo interpretation. The number of samples from each type ranged from three to seven, and was based on the distribution and abundance of the type in the mapping area (e.g., more samples were selected for vegetation types that were common and widely distributed). Plots were selected to be geographically and ecologically representative of the study area.

Field data collection methods largely followed methods for plant community classification developed by the California Native Plant Society (CNPS: Sawyer and Keeler-Wolf 1995), which are in conformance with USGS/NPS standards. Although CNPS methods use point intercept transects, for this project, plant species composition and percent cover were measured using a modified relevé approach. This approach was believed to provide data that were more representative of sampled polygons than would have been provided by point intercept transects.

Field crews selected plot locations to provide the best possible representation of the vegetation within the polygon. Plots were either square or rectangular in shape. Plot size was dependent upon the configuration of the polygon and the plant community type. For herb and shrub-dominated communities, plots were 400m^2; for forest and woodland communities, plots were 1000m^2.

Percent cover of each plant taxon was documented as both an actual percentage and as a cover class. These data were used to characterize the layering of vegetation present in the communities. The information on vegetation layers collected for this project provided more detail than is provided by using standard CNPS methods. Ten height classes were included: moss/lichen, low herb, medium herb, low shrub, high herb/medium shrub, high shrub, low tree, low/medium tree, medium/high tree, and high tree. These data facilitated development of the classification system and will be useful in fire management (e.g., fire behavior predictions, prescribed fire planning).

Following data collection, Todd Keeler-Wolf from the CDFG entered the plot data into a Paradox database, and conducted Twinspan analyses to determine appropriate divisions in the classification. Preliminary analyses resulted in identification of 55 alliances. Within these alliances were 57 plant associations and 95 vegetation types represented by one or more plots. In addition to developing the classification, a key was produced to facilitate rapid identification of plant communities in the field.

Conclusions

The vegetation map and classification resulting from this project will be used as a planning tool for a wide variety of resource management and research projects, from prescribed fire planning to habitat suitability analyses for wildlife. Additionally, data collected in the field has augmented plant inventory data for the parks. The map and data will document reference conditions against which future change can be measured and monitored. The releve plots, for example, could be used as long-term monitoring plots to detect changes in plant community composition.

The value of the map and classification are significantly increased by the fact that these planning tools are regional in nature. Mapping and classification are tasks that are ideally suited to regional, or ecological approaches, rather than strictly park-specific approaches. Vegetation mapping that is approached at a regional scale facilitates a bioregional approach to land management as resources are viewed within a larger ecological context. For example, when formulating management plans for coastal prairie grassland, Point Reyes vegetation managers will have immediate knowledge of the presence and abundance of this plant community type within all areas covered by the map, both within and outside of Point Reyes National Seashore. With this information, the significance and relative rarity of Point Reyes' coastal prairie becomes more readily apparent and management efforts can be tailored to this information.

Multi-Species Inventory and Monitoring at Point Reyes NS

An inventory and monitoring program for amphibians, reptiles, and small/medium mammals was implemented at Point Reyes National Seashore in 1996. The project was funded by USGS monitoring funds and by the first year of SFBAN I&M program funds. The goal of this work has been to determine whether fairly simple, yet scientifically-based techniques could be used to track vertebrate populations across a variety of habitat types including grasslands, riparian, scrub, and coniferous forests. Using a combination of three types of traps, artificial cover boards, and remote-triggered cameras, the presence of 58 species of vertebrates has been documented during the first three years of operation. The protocol worked well in the variety of habitats sampled and could easily be applied to other situations. The program is cost effective and can be implemented with a single field person. Modifications to the trapping scheme are being tested to further improve efficiency and effectiveness.

The sampling arrays are a modified method developed by Robert Fisher of the USGS-Western Ecological Research Center (WERC) San Diego Field Station (unpublished). Each sampling array consists of three arms with a replicated pattern of pitfalls, funnel traps, boards, and Sherman traps. The complete array has seven pitfall traps, three funnel traps, six cover boards, and six Sherman traps. A TrailMaster camera is placed along a game trail within 50 m of every fourth sampling array. Four sampling arrays are installed at each site to be sampled. This allows for replication within a local area as well as the opportunity to sample the variation in microhabitat in each habitat. Sets of four sampling arrays have been deployed in five of the primary habitats at PORE: bishop pine (2 sites), Douglas fir (2), coastal scrub (2), grassland (1), and riparian (1). This results in eight sets of arrays for a total of 32 individual arrays.

There have been about 45,000 sampling days for all sites and all traps combined. A total of 32 species have been caught. This includes 1 species of frog, 5 species of salamander, 6 species of snakes, 2 species of lizards, 12 species of mammals, and 6 species of birds. There have been a total of over 3,000 captures to date. Nearly all these animals were weighed and measured to obtain additional data on their overall health and condition. Additionally, a TrailMaster camera was in operation continuously at each of the eight sites. Approximately 4,000 photographs of wildlife including 37 species of wildlife, mostly mammals and birds (a non-target group), have been taken.

The success of the I&M program for terrestrial vertebrates at PORE is greatly encouraging. While some refinement of the protocol is in order, early results indicate that these techniques have worked quite well. The techniques sample a wide variety of animals, including many species, which are not often included in monitoring programs. It is relatively simple to establish the trap sites in the field and the program can be run with a minimum number of people. The sampling scheme used can be readily expanded to encompass other habitats and/or to allow for more intensive sampling. Hence, it is intended to be as versatile as possible in how it is implemented. Additionally, results from one park area could be compared with data from other park areas. Implementation of the proposed inventory and monitoring program would assist I&M programs elsewhere by providing a practical model, especially for medium and small parks.

Multi-Species Inventory and Monitoring at Golden Gate NRA

Begun in 1988, GOGA started surveying small vertebrate amphibians, reptiles and mammals in many habitats (Howell 1992). The protocols applied include a stratified random sampling design based on habitat type as classified by the California Department of Fish and Game (CDFG 1988). This project was funded by a number of sources over the years including GOGA, Earthwatch, and the California Department of Fish and Game. Surveys have been conducted using line transects, variable circular plots, live traps, Sherman box traps. Pitfall traps are used if determined necessary based on field observations. Over 500 plots have been sampled and an additional 20 plots in upland habitat, forests, and around coastal lagoons will be completed this year. The additional funds applied from the SFBAN I&M funds in 2000 supplement funds from the USGS State Partnership Program and completes the inventory. Data have been entered into an MS Access database for use in a GIS system.

Muir Woods Inventory

Funded through the Pacific West Region, an inventory of sensitive wildlife species in old-growth forest was initiated in MUWO in 1997 and is nearing completion. This inventory work will complete the objectives outlined in the NPS Natural Resource Challenge Initiative thereby minimizing MUWO's needs for I&M funds allocated to the SFBAN of parks.

The avian inventory was completed in 1999 with 55 species of birds documented. The most common species encountered was the Pacific-slope flycatcher, a species of conservation priority. Ten species of management concern, as defined by the Office of Migratory Bird Management of U.S. Fish and Wildlife Service and the Partners-in-Flight program, were found. All but one was determined to be breeding or have potential to breed within MUWO. Several methods were employed in an effort to detect the federally threatened marbled murrelet, including fixed station monitoring, eggshell searches and shore-based ocean surveys at Muir Beach. No marbled murrelets, however, were found during the breeding season.

Field work for the inventory of mammalian species within MUWO was completed in 1999 with the final report in preparation. No evidence of Point Reyes mountain beaver presence was found during targeted surveys. Preliminary results from small mammal trapping and remote camera arrays documented 18 native mammals as well as domestic dogs and cats. In addition, 2 herptofauna species were encountered. Thirteen species of mammals were found in coast redwood and Douglas-fir habitat, 10 species in grassland habitat, 6 species in California bay habitat, and only 3 species in coast live oak habitat. Dusky-footed woodrat (primary prey species of northern spotted owl) detections were highest in Douglas-fir forest. Most species exhibited some preference for specific habitat types or slope position (e.g. valley floor versus mid-slope). Finally, an inventory of bats was begun in 1999 and will be completed in 2001. This inventory is employing several methods to detect bats including guano traps in redwood hollows, acoustic surveys and spotlighting, mist-netting, and radio-telemetry. To date, 10 species of bats have been confirmed in MUWO including several species of concern in California. This combination of methods has been able to document maternity roosts as well as migration pulses of bats through MUWO.

Avian Inventory

The I&M Program funded an inventory of landbirds, shorebirds and waterbirds at GOGA, FOPO, PRES and PORE between 1998 and 2000. The waterbird and shorebird inventory has been completed, and the landbird inventory will be completed in October 2000. PORE and GOGA set up a cooperative agreement with Point Reyes Bird Observatory to conduct the inventory. PRBO provided a final report for the waterbird and shorebird inventories (White, 1999), and the report on the landbird inventory is pending. All information to date has been included in NPSpecies and NRBib.

A total of 6 surveys of Tomales Bay, Drake's Bay, Drake's Estero and Limantour Estero were simultaneously completed in the winter of 1999 and 2000, and a total of seven surveys were completed at Abbott's Lagoon, Bolinas Lagoon, Rodeo Lagoon, East Fort Baker, and Fort Point. Six surveys were considered enough to detect 90% of wintering shorebird species and four surveys to detect 90% of wintering waterbirds (Kelly and Tappan 1998). Each large estuary was separated into subsections and teams of 2 people were enlisted to cover each area. At all sites, in addition to counting shorebirds and waterbirds, biologists also counted belted kingfishers, gulls and raptors. Data provided by PRBO was in tabular form with associated UTMs for each location. A list of species and associated abundance were provided for each species observed, and presence/absence data was provided for gulls. Species richness information was also included for each location. Many of the species inventoried have special state or federal status including such species as the western snowy plover, brown pelican, white pelican, double-crested cormorant, red head duck, and peregrine falcon.

The landbird inventory established point counts along transect lines throughout the parks and stratified by habitat type, based on the draft vegetation map of the parks. Surveys were conducted during the breeding season and each transect was visited a minimum of 3 times. Protocols are following the national standard, as per Ralph *et al*. (1993 and 1995).

Data Inventory

The initial phase in the development of the SFBAN's biological inventory study plan involved the compilation of all existing data concerning the occurrence of vascular plants and vertebrates within the parks. A data inventory group stationed at GOGA visited all the network parks between May and September 2000 to collect relevant information on species occurring within the parks. This data was used to update the NPSpecies and NRBib databases provided by the I&M Program. A more thorough description of this process and the initial results are presented in Section III of this report.

SECTION III: PROJECT DESCRIPTION

Step 1: Data Inventory of Existing Information on Vertebrates and Vascular Plants

Overview

In May 2000, the data inventory group began collecting all existing information on vertebrates and vascular plants within the San Francisco Bay Area Network parks. This process continues as new data sources emerge and existing data is refined. During this phase, information in the form of species checklists, research and other technical reports, management plans, wildlife observation records and photographs, and museum/university voucher specimen collections were compiled and incorporated into the NPSpecies and Natural Resources Bibliography (NRBib) databases. A summary of relevant inventory work, technical reports, and species lists utilized by the data inventory group is presented in Appendix A. Updated species lists were generated for each of the Network parks and were used to determine if the NPS goal of 90% inventory completeness was met. Collected information and generated species lists were reviewed during an inventory scoping workshop held in early August.

NPSpecies Update

The first objective was to populate the NPSpecies database with the most current vertebrate and vascular plant species lists available. In March 2000, the I&M Program office provided the Network with a beta version of NPSpecies populated with existing NPFlora and NPFauna records. Since records were incomplete or missing for most of the Network parks, new records were added from as many sources as possible, including Man and the Biosphere databases, park checklists, electronic databases, field reports, and museum voucher specimen collections. These lists are as inclusive as possible. To date, over 430 vertebrate species and some 2400 vascular plant species have been added to NPSpecies databases (Table 2). These species lists continue to be updated as new occurrence and categorical data references are acquired and as existing lists are further refined. Updated and verified databases will be returned to the I&M Program office by October 2000 for incorporation into the web-based version of NPSpecies.

Table 2. Total number of species records in NPSpecies.

Taxa	GOGA	PORE	PINN	MUWO	JOMU	EUON
Amphibians	18	11	13	5	0	0
Birds	384	448	155	89	76	0
Fish	32	28	3	3	0	0
Mammals	69	81	59	39	0	0
Reptiles	34	17	29	6	0	0
Plants	1376	922	720	297	341	0

NRBib Update

ProCite databases containing Natural Resources Bibliography (NRBib) entries were last updated for the Network parks in 1997. Over the last three months, a great deal of time was spent bringing NRBib up to date in order to provide a current resource for referencing species occurrences. This effort entailed (a) examining the Investigator's Annual Report (IAR) records for each park to identify studies which had been initiated and/or completed within park boundaries, (b) conducting on-site visits to each park to locate new reference materials (field study reports, management plans, research proposals, memos, etc), and (c) interviewing park managers and staff in order to locate additional sources of information. A search of bookshelves, filing cabinets, central files, drawers, and desktops has resulted in over 460 new NRBib entries. Currently, there are some 4,000 NRBib records for the Network parks (Table 3). In addition, pre-1997 records for PINN are being updated from an off-site storage facility identified during the August scoping workshop.

During this initial data inventory phase, concentration was placed on updating NRBib for all bibliographic references physically located within park offices and storage areas. However, several additional non-NPS sources of information were identified and will need to be fully investigated. These include graduate student theses and dissertations, published and non-published reports stemming from university-based research conducted within park boundaries, and reports from local, state, and federal agencies. Although some of these materials were found in park records, most remain with their parent institutions.

Table 3. Number of current NRBib records for SF Bay Network parks.

	GOGA	PORE	PINN	MUWO	JOMU	EUON
Pre-1997	1398	791	220	95	21	0
1997-2000	1622	993	265	113	23	0

Voucher Specimens

Local natural history museums were searched for voucher specimens collected within Network park boundaries. Because of the broad scope and variable status of these collections, only a fraction of the collections believed to be viable sources of voucher specimens for the parks were investigated. However, specimen records from the institutions were searched to confirm the presence of many species and to add additional species to the park lists. Overall, there appears to be a tremendous amount of voucher material available for the Network parks, although the number of specimens and the accessibility of collection information vary widely among parks and taxa. A summary of an example collection is given in Table 4.

A significant portion of the museum material found was not fully cataloged, verified for accuracy, or entered into electronic databases. In addition, it is believed that numerous specimens exist within individual university departments and in private researcher collections. Thus, a full accounting of voucher specimens is currently incomplete and will require additional effort by the Network. Specific recommendations are given in Section IV.

National Park Service collections and all existing ANCS+ records were reviewed. ANCS+ databases were available for GOGA, PORE, and PINN, but not for MUWO or JOMU. However, several MUWO entries imbedded in the GOGA database were unable to be extracted. ANCS+ records will be exported to an Access database and sent to the I&M Program office for incorporation into the web-based version of NPSpecies.

Table 4. Number of specimens likely collected within Network park boundaries—Museum of Vertebrate Zoology, University of California, Berkeley. The number of species represented by these records is given in parentheses.

Taxa	GOGA	PORE	PINN	MUWO	JOMU	EUON
Amphibians	167 (10)	1053 (8)	196 (8)	74 (6)	---	---
Birds	232 (63)	373 (82)	34 (22)	2 (2)	---	---
Mammals	561 (36)	1343 (58)	155 (22)	1 (1)	---	---
Reptiles	91 (12)	136 (10)	205 (21)	6 (4)	---	---

Observation Records

Although most parks keep records of wildlife observations submitted by staff and visitors, these are usually unconfirmed and of little value in determining the actual presence of a species. Observation cards for each park were reviewed but only those observation records identified by park staff as coming from reliable sources were utilized. Photographs taken within the parks were considered as observation events, but only if the species and the photo locations could be clearly identified. Photographs collected during multi-species array sampling at PORE and GOGA are a rich source of records.

Evidence Records in NPSpecies

The species lists generated during this initial data inventory phase were derived from a variety of sources including existing databases (NPFlora and NPFauna), both published and non-published checklists, reports from previous field investigations, and voucher specimen collections. They define the broadest set of species that are believed to occur within the Network parks given all past efforts to define those sets. In order to refine this information, attempts were made to link each species record in NPSpecies with at least one piece of evidence derived from either field investigations identified in NRBib, voucher specimen collections, or verified observation records. Although this process continues, some preliminary findings are presented in Table 5.

Dataset Catalog

When the initial data inventory phase began in May, a finalized MS Access version of Dataset Catalog was unavailable. Compiling metadata on electronic datasets was delayed until work was completed on the program. However, GIS layers for each of the Network parks were reviewed and compiled into a list of available coverages (Table 6). The current goal is to populate Dataset Catalog with all existing database information over the next few

Table 5. Number of species recorded vs. those confirmed to occur in the SFBAN Parks.

Taxa	Park	Number of Species		
		Recorded in NPSpecies	Confirm through reference, voucher, or observation	Percent of Total
Amphibians	GOGA	18	13	72
	PORE	11	3	28
	PINN	13	13	100
	MUWO	5	2	40
	JOMU	---	---	---
	EUON	---	---	---
Birds	GOGA	384	308	80
	PORE	448	312	70
	PINN	155	153	99
	MUWO	89	63	71
	JOMU	76	76	100
	EUON	---	---	---
Fish	GOGA	32	11	34
	PORE	28	12	43
	PINN	3	3	100
	MUWO	3	3	100
	JOMU	---	---	---
	EUON	---	---	---
Mammals	GOGA	69	52	75
	PORE	81	48	59
	PINN	59	56	95
	MUWO	39	31	79
	JOMU	---	---	---
	EUON	---	---	---
Reptiles	GOGA	34	27	79
	PORE	17	1	6
	PINN	29	29	100
	MUWO	6	1	17
	JOMU	---	---	---
	EUON	---	---	---
Vascular Plants	GOGA	1376	0	0
	PORE	922	31	3
	PINN	720	559	78
	MUWO	297	246	83
	JOMU	341	250	73
	EUON	---	---	---

years. A data management plan will be developed to define the protocols for the creation of metadata and standardize the process for all Network parks (see Step 5: Network Data Management).

Table 6. Existing GIS data themes for the San Francisco Bay Area Network parks.

GIS Layer	GOGA^	PORE	PINN	JOMU	EUON
Boundary	x	x	x	x	--
Topography	x	x	x	x	--
Hydrology	x	x	x	x	--
Hypsography	x	x	x	x	--
Elevation (DEM 30m)	x	x	x	x	--
Vegetation	x	x	P	x	--
Soils	x	x	P	x	--
Trails	x	x	x	--	--
Roads	x	x	P	x	--
Structures	P	x	x	--	--
DOQQs	x	x	x	x	--
Digitized USGS Maps*	x	x	P	x	--
Geology	P	x	P	--	--
Fire	--	P	x	--	--
T&E Species:					
Rare Plants	P	P	--	--	--
Animals	P	P	P	--	--

^GIS layers for MUWO, FOPO, and PRES are managed by GOGA
*This includes a variety of GIS layers obtained from USGS maps that can be found in Dataset Catalog.
X = complete
P = partial (this includes the addition of new land without GIS information and incomplete data themes).
-- = data theme does not exist

Step 2: Development and Prioritization of Park-Specific Inventory Needs

Overview

During the week of August 7, 2000, the SFBAN initiated the development of this study plan by hosting an inventory workshop at Fort Mason Center in San Francisco. Participants included resource management personnel from all the network parks, USGS staff, university professors, and representatives from other associated agencies and research organizations (Appendix B). Results from the data inventory phase were presented to the workshop participants for their review, to identify fundamental data gaps, and to guide the discussion of necessary inventory projects. The workshop objectives were to:

- Discuss, identify, and review the status of species lists for vertebrates and vascular plants for the parks.
- Discuss, identify, and review the species of special interest at each of the parks.
- Discuss, identify, and review the habitats of special interest at each of the parks.
- Develop inventory project priorities for meeting the NPS mandated 90% completeness standard for presence/absence data and distribution and abundance information on significant biological resources.
- Discuss and recommend methodologies and costs for completing project priorities.

During the workshop, participants broke out into working groups according to their expertise in vegetation, wildlife (birds, mammals, reptiles, and amphibians), aquatics (fish and invertebrates), or terrestrial invertebrates. Although

beyond the scope of the objectives presented by the I&M Program, the presence of several threatened and endangered (T&E) invertebrate species and the defining role that invertebrates play in several unique habitats within the SFBAN necessitated the need for inclusion of invertebrates in the working groups.

The break-out groups reviewed the existing information presented by the data inventory group to develop inventory completeness values by taxa for each of the Network parks (Table 7). The groups then developed recommendations for further efforts by the data inventory group that will help the Network move closer to the 90% completion level for each taxa. Finally, field inventory projects were designed to address data gaps that can not be resolved through further data mining.

Table 7. Percent inventory completeness by taxa for the SFBAN parks.

Park	Mammals	Birds	Herps	Freshwater Fish	Marine Fish	Plants
PORE	85%	95%	80%	95%	<10%	90%
GOGA	90%	85%	80%	95%	<10%	80%
PINN	90%^	90%^	90%^	90%^	---	90%^
MUWO	90%	90%	85%	95%	---	90%
JOMU	20%	20%	0%	---	---	80%
EUON	0%	0%	0%	---	---	0%

^ 0% for PINN new lands

The groups presented their inventory projects to the entire workshop ranked first by general inventory need, followed by species of special concern, and finally according to special habitat type. The possibility of outside funding sources was also considered in the ranking process. Selecting the top ranked projects from each working group until all available funds had been allocated created the final list of projects proposed for funding (Appendix C). These projects are presented as general species inventories, inventories of species of concern, or inventories of habitats of concern. (Tables 8-10). A final review of the project list insured that the guidelines presented by the NPS Inventory and Monitoring Program had been followed to the closest extent possible. A portion of the unfunded projects is described in Appendix D.

Inventory Priorities

The greatest inventory needs were found to be at JOMU, EUON, and the newly acquired lands at PINN where no systematic inventories have been completed for vascular plants or any vertebrate species (Table 8). PORE, GOGA, and the remainder of PINN lands have satisfied inventories to the 90% completeness level for vascular plants, reptiles, amphibians, and freshwater fish. The workshop recognized that inventories for bats at PORE, GOGA, and PINN are needed to meet the 90% level for mammals (Table 8).

Data gaps in species lists emerged not due to the lack of inventories but due to the incompleteness of the NPSpecies and NRBib databases. For example, significant presence/absence data was missing for marine fishes at PORE and GOGA. Workshop participants also agreed that the SFBAN does not have sufficient information on the presence/absence of T&E terrestrial invertebrates. This data may exist with other local agencies and universities, such as the CDFG or local universities, but searching for data and reports from these organizations was beyond the scope of the data inventory phase. These data gaps highlighted the need to continue the data inventory phase under the direction of an Inventory Coordinator for the SFBAN (Table 8).

Table 8. General species inventory projects. See Appendix B for detailed descriptions.

Project Title	Park	Status
Inventory Coordinator	All	Funded
Vegetation Inventory	JOMU, EUON	Funded
Vascular Plant Inventory of New Lands	PINN	Funded
Bird Inventory	PINN, JOMU, EUON	Funded
Bat Inventory (structures)	EUON, GOGA, JOMU, PINN, PORE	Funded
Small Mammals and Herpetofauna Inventory	PINN	Funded
Small Mammals and Herpetofauna Inventory	EUON, JOMU	Funded
Riparian Aquatic Species Inventory	PINN	Funded
Coastal Biological Resources Inventory	GOGA, PORE	Partially Funded
Sub-tidal and Deep Water Biological Resources Inventory	GOGA, PORE	Partially Funded
Bat Inventory (natural habitat)	EUON, GOGA, JOMU, PINN, PORE	Unfunded
Dune Invertebrate Inventory	PORE/GOGA	Unfunded
Complete Accuracy Assessment of Vegetation Map	PORE, GOGA	Unfunded
Vegetation Map	PINN	Unfunded

Inventories of Species of Special Concern

A number of federally and state listed T&E species (Table 1) and species of interest or concern to the state and other organizations occur within the SFBAN of Parks. Thorough abundance and distribution data for many of these species have been gained through intensive monitoring programs within the Parks. The workshop identified several species, however, for which data are non-existent or only partially complete, including federally listed T&E species, state listed species, unlisted species that are indicators of ecosystem health, and exotic species (Appendix E).

Many of these species will be surveyed via general inventory projects. Other species, however, necessitated the need for more specific inventory studies, such as the salt-marsh harvest mouse and rare plants (Table 9).

Inventories of Areas of Special Concern

Workshop participants identified several habitat types within the SFBAN which are rare in and of themselves, and/or provide appropriate habitat for rare plant and animal species. In many cases, the SFBAN does not have adequate inventories or spatial distribution of these ecosystems to appropriately manage for their long-term health.

Table 9. Inventories of species of concern. See Appendix B for detailed descriptions.

Project Title	Park	Status
Salt Marsh Harvest Mouse and Point Reyes Jumping Mouse Inventories	GOGA, PORE	Funded
Bat Inventory (structures)^	EUON, GOGA, JOMU, PINN, PORE	Funded
Riparian Aquatic Species Inventory^	PINN	Funded
Rare Plant Inventory	GOGA, PORE	Partially Funded
Determine Distribution and Abundance of Twenty-five High Priority Non-Native Invasive Plants	GOGA, PORE	Unfunded
Inventory Aquatic Vascular Plants	PORE	Unfunded
Inventory of Invasive Non-native Plants	PINN	Unfunded
Rare and Endangered Plant Inventory	PINN	Unfunded
Lichen Inventory	PINN	Unfunded
Bat Inventory (natural habitat)^	EUON, GOGA, JOMU, PINN, PORE	Unfunded
Inventory Ashy Storm-petrels	GOGA, PORE	Unfunded
California Freshwater Shrimp Survey	PORE	Unfunded
Inventory of Native and Non-native Freshwater Bivalves	GOGA	Unfunded
Dune Invertebrate Inventory^	PORE/GOGA	Unfunded
Hymenoptera Inventory	JOMU	Unfunded
Cave Invertebrate Inventory	PINN	Unfunded

^ Also considered as a general species inventory need.

The coastal and open water marine environments surrounding PORE and GOGA are recognized as some of the most productive in the world. A diverse assortment of cetaceans, pinnipeds, birds, marine fish, marine invertebrates, and algae thrive on the nutrient rich waters found there. Commercial fishing, recreational activities, and shipping traffic out of San Francisco, however, are a constant threat to these precious marine resources. Many federal laws require Parks to assess the impacts of their operations on marine life, particularly fisheries (Magnuson-Stevens Act). The absence of fish species inventory data makes this assessment difficult. For the NPS to document the effect of anthropogenic or natural disturbances to the marine environment there must be existing information for comparative purposes. Inventories of the coastal and open water marine environments must be conducted to insure the health of these marine environments (Table 10).

The SFBAN supports numerous rare and sensitive native plant communities including coastal freshwater marsh, coastal dune, coastal bluff, riparian forest and scrub, northern coastal salt marsh, Bishop pine forest, and oak woodland. Current vegetation mapping projects have provided preliminary information on some of these rare and sensitive plant communities, but map scales are too coarse to identify small patches of these habitats. Therefore, additional, more comprehensive information and focused planning are required to accurately document and ensure long-term protection of these critical biological resources (Table 10).

Table 10. Inventory projects for areas of special concern. See Appendix B for detailed descriptions.

Project Title	Park	Status
Coastal Biological Resources Inventory^	GOGA, PORE	Partially Funded
Sub-tidal and Deep Water Biological Resources Inventory ^	GOGA, PORE	Partially Funded
Complete Wetland Inventory	PORE	Unfunded
Wetland Inventory	GOGA	Unfunded
Mapping and Characterization of Bishop Pine, Riparian, Coastal Bluff and Oak Woodland Plant Communities	PORE, GOGA	Unfunded

^ Also considered as a general species inventory need.

Step 3: Study Designs and Methods

General methods for completing the proposed inventory projects are discussed below according to the taxa that are being addressed. More specific methods can be found in the project descriptions (Appendix C).

Vegetation

Vegetation inventories have been divided into four main categories: vascular plant inventories, vegetation mapping, rare species (including plants that are federal, state, or CNPS listed) and habitat inventories, and non-native species inventories.

<u>General Vascular Plant Inventories</u>

Some lands within the SFBAN have no general vegetation inventory data. Vegetation plots or releves will be established throughout the park areas where inventories have not been completed. All plants within these plots will be recorded. These data will then be used in the development of vegetation maps for the various park units. In smaller areas, plots will be randomly located throughout the park area. In some cases, such as at EUON, where native plant areas are very small, a simple search and record method will be used to document species. In larger areas, a stratified sampling design will be applied to distribute the plots among all habitat types. Many parks have unique habitats and microclimates, which will be under-represented if a random sampling design is applied. These habitats will be sampled preferentially to assure that species are recorded from these sites.

The beginning of any inventory effort should involve an extensive search of local herbaria and universities to identify collections and studies that have been completed in these park units. Such work will assist in the verification of current plant species lists. Consolidation of available information for the SFBAN began in May, 2000 (see Section II). Work is needed in all SFBAN units to substantiate collections and obtain representative samples of those species currently without vouchers. All projects completed in the SFBAN parks in the future will include collection and preparation of herbarium specimens to document the distribution and presence of species.

Vegetation Mapping

PORE and GOGA are in the final stages of conducting an accuracy assessment on a photo interpretation based vegetation map (see Section II). For PINN, EUON, and JOMU, vegetation plots (releve) established during vegetation inventories can be used, along with plots installed in other areas of the parks, as training data to develop vegetation maps. Aerial and/or satellite imagery will be used with vegetation plot data to refine plant community classifications. These data can also be used to delineate land cover polygons using aerial photo interpretation or image processing techniques.   Field data will also be used to test the accuracy of the photo interpreters or image processing routine and to determine if changes are needed to the classification (land-cover polygon labels) or if additional descriptions of vegetation associations/alliances are needed. Polygons will be selected for accuracy assessment following the methods established by the USGS-NPS vegetation mapping group. Vegetation maps for each of the Network parks are vital to assist with planning surveys for rare plants, non-native plants, unique habitats, and wildlife.

Rare Plant Species and Habitat Inventories

Successful management of rare plants requires comprehensive information on the locations, size, vigor, and population dynamics of all plant populations to be managed. Rare plant species are specific to each of the SFBAN parks, and thus each of the SFBAN parks will develop a prioritized list of species and habitats targeted for inventories. By definition, these species and habitats are uncommon and may not be encountered in other inventory projects, at least not at levels that provide adequate distribution and abundance information. To obtain information on these species, species' specific methods will be required and surveys will be focused on habitat with potential to support target species. Studies that attempt to look at the distribution of rare plants or habitats by randomly sampling an entire area would be cost-prohibitive and time consuming. Likewise, some species are so limited in distribution, or are so habitat specific, that random sampling can be easily replaced by census within target habitats.

The following general strategies will be applied to maximize the effectiveness of rare plant inventories. First, all existing listed plant occurrence records for each park will be reviewed. Second, habitats with potential to support plants will be identified. This will be accomplished more successfully in areas with current vegetation maps. Last, field surveys will be completed to document occurrences.

All populations will be documented using the CNPS-based system already in place at some of the network parks. Surveys will be conducted over a 2-4 year period (depending on allocation of funding) to ensure that all rare annual plants are documented (if rainfall is low, annuals may not germinate, surveys in two years will buffer against a low rainfall year). Data will be entered into a database for use in a GIS system.

Non-native Species Inventories

The spread of non-native plants represents a significant threat to the biological diversity of the SFBAN parks. Research on these invasive plants within the parks illustrates their ability to alter community composition and

reduce the diversity of native plants, insects, and small mammals. These species can quickly invade disturbed and undisturbed areas, displacing native vegetation, and permanently changing the physical structure of the ecosystem. Even if these species are removed, the restoration of these ecosystems may take a long time, or may never occur. The key to protecting ecosystems is to prevent the initial invasion of these species into new areas. To accomplish this goal, systematic surveys for these species must be completed so removal efforts can be focused in areas most at risk for habitat loss.

In general, a tiered approach will be applied to the inventory of invasive non-native species, based on invasiveness, extent of populations, and proximity to unique native habitat types. Smaller populations with limited distributions will be mapped in the field using GPS equipment. Species that are more widespread will be mapped using aerial methods, such as helicopter surveys, which allow large amounts of land to be covered in a short amount of time. Initial surveys will be followed up by detailed ground surveys to document the extent of populations. In areas where initial surveys determine that populations are extensive and ground surveys would be cost-prohibitive, highly sensitive habitats of concern will be targeted for surveys.

Mammals/Reptiles/Amphibians

Inventories for mammals, reptiles, and amphibians within the SFBAN will employ methods already established by NPS and USGS biologists. These methods have been tested for their repeatability and ability to sample different habitat types representatively.

Sampling Arrays

Sites will be inventoried for small/medium mammals, reptiles, and amphibians using a series of four sampling arrays (see Section II). This allows for replication within local areas as well as the opportunity to sample the variation in microhabitat in each habitat. Sites will be selected based on the uniformity of the habitat type, access, and site suitability for the construction of the array scheme.

Each sampling array consists of three arms with a replicated pattern of pitfalls, cover boards, and Sherman traps. The arrays are modeled after work conducted by Robert Fisher of the USGS-WERC (unpublished). Starting with a central pitfall trap, each arm extends 5 m to a second pitfall trap and another 5 m to a third pitfall. A funnel trap is placed on the ground between the second and third pitfalls. Pitfall traps consists of 5-gallon plastic buckets. A 12" high drift fence runs the full 10 m along each arm and functions to lead animals toward the traps. Five meters beyond the end of each drift fence are two cover boards and a pair of Sherman traps. Hence, each of the three arms is 15 m long. The complete array has seven pitfall traps, three funnel traps, six cover boards, and six Sherman traps.

A TrailMaster camera will be deployed in association with each set of four arrays to record carnivores and other incidental wildlife. Since the cameras are most effective when set up across a game trail, the cameras will not be used in close association with the array, but at the best looking spot within 50 m of each array. This will allow

recording of wildlife in the general vicinity without being limited to exact sites which are not likely to be representative of carnivores. Camera sites will not be baited since that tends to concentrate the activity of carnivores in one area with the result that many photographs are taken of a few individuals.

Amphibian Surveys in Aquatic Environments

Sampling arrays do not allow for inventories of amphibians in an aquatic environment. The basic techniques for conducting aquatic surveys for amphibians are visually based and include: 1) using binoculars to scan for basking frogs, 2) slowly walking in the water or on the adjacent bank while visually searching for eggs, larvae, and adult amphibians, and 3) using dip nets to find and capture larvae and adults. After scanning a site with binoculars, a visual search of the banks, rocks, logs, pond bottom, and the surface of floating vegetation can locate many amphibian species. In most areas, poor water clarity will require dip netting for a complete and accurate survey. Dip netting is used to locate and capture amphibians. The net should be swept in all types of microhabitats, including plunge pools, riffles, slow moving backwaters, beneath overhanging banks, and within floating and emergent vegetation. Amphibians will be captured in order to verify identification, collect biological data, and photograph the animal.

Bats Surveys

Surveys for bats must be completed independently from other vertebrate surveys due to their unique life history. Potential roost sites can be surveyed for the presence or absence of bats through guano searches and observations of bats leaving the roost at dusk. Identification of bats to species can be done through spotlighting roosting bats or through acoustic monitoring. Acoustic monitoring stations record sounds emitted by bats, which can be identified to the species level by bat specialists. Mist-netting for bats at selected sites is another widely used technique for inventorying bats and will be employed within the SFBAN as necessary.

Birds

Point Count Censuses

Repeatable point count censuses will be conducted to inventory landbirds at PINN, JOMU, and EUON, following a standardized variable circular plot protocol, as recommended by the NPS I&M program and described in Reynolds *et al*. (1980) and Ralph *et al*. (1993). The repeatable point count method has been used by the Point Reyes Bird Observatory to inventory birds at PORE and GOGA since 1995. Transects consisting of multiple point count census stations spaced 200-250 m apart from one another will be established. At each census station a five-minute census will be conducted. All birds detected within a five-minute period at each station will be recorded, and the distance from the center of the census point to each detection will measured separately. Flyover birds in the census area will be recorded separately. The type of detection (song, visual or call) will also be noted for each individual, in that hierarchical order. Counts begin around local sunrise and continue for no more than four hours in order to restrict the census to peak singing hours. Counts will not be conducted during poor weather conditions, when bird activity

levels and detection probabilities are reduced. All point count stations will be visited three times between late April and early July, with a minimum of 10 days between visits, to increase detection probabilities of less common species. Additionally surveys will be conducted in the winter months at PINN to detect winter residents, but will not follow the variable circular plot survey method since birds do not sing or hold territories in the winter months. Instead, birds will be surveyed using timed area searches in various habitat types.

Vegetation Assessment

Vegetation data is also collected at point count stations to relate differences in bird species composition and abundance to differences in vegetation. Vegetation will be assessed using the standard relevé method (Ralph *et al*. 1993). General habitat type will be assessed (Sawyer and Keeler-Wolf 1995, Shuford and Timossi 1989), basic characteristics of the site will be recorded (aspect, slope, presence/absence of water, # snags and logs), and cover and mean height of each vegetation stratum (tree, shrub and herb) will be estimated along with mean diameter at breast height for the tree layer. Within each vegetation stratum the species composition will be determined and each species' relative cover of that stratum recorded. UTM coordinate data will be collected at each point count station.

Freshwater Fish and Invertebrate Inventories

Procedures to inventory freshwater aquatic life will depend upon the community of interest. Surveys to identify suitable habitat conditions will delineate habitat types, such as pools and riffles, and are necessary to minimize sampling of unsuitable habitat for the taxon or community of interest. Recent aerial photos and USGS topographic maps will be used to identify on a coarse scale, potentially suitable areas.

Fish

Fish sampling procedures (e.g., direct observation) will be utilized to extensively sample large areas, determine species composition, and relative abundance. Details on direct observation sampling are described in Thurow (1994). Inventories in park waters will require both passive and active sampling techniques to target fish at various life stages. Larvae and eggs will be sampled passively within riverine systems. Snorkel or seining surveys over large distances will likely be conducted for adults and juveniles. All surveys would require completion by fishery biologists familiar with the taxa or community of interest and knowledgeable regarding suitable habitat conditions.

Invertebrates

Benthic macroinvertebrates will be sampled from riffle stream units in accordance with the CDFG Rapid Bioassessment Protocol (CDFG 1999). The study design is intended to identify point and non-point pollution sources, but also provides valuable inventory and food source data for fish and amphibians. Riffles are sampled across three randomly selected transects with a D-frame kick net. The samples from each transect are analyzed separately for higher statistical power. In the laboratory, 300 macroinvertebrates are randomly selected for identification to the lowest taxonomic classification.

Survey procedures for the federally endangered California freshwater shrimp will be consistent with standard gear restrictions and take limitations established by the surveyor's Section 10 (Endangered Species Act) permit. Typical sampling procedures will include the identification and quantification of suitable habitat based on gradient, perennial flow, and presence of overhanging vegetation and exposed roots. Shrimp sampling will occur in suitable habitat using aquatic dipnets and butterfly nets (Fong 2000).

Similarly, surveys for non-native clams and mussels will be preceded by habitat surveys to document the location of depositional areas to place upstream and downstream limits for survey activities. Subsequent biological survey activities will consist of either timed visual surveys or use of clam rakes along belt transects across the creeks (Watson *et al.*, 1998).

Marine Fish and Invertebrate Inventories

Current presence/absence lists of marine fish at PORE and GOGA are estimated to represent <10% of species actually occurring within park waters (Table 7). Marine fish surveys in intertidal and open water habitats will be conducted separately due to their natural differences in accessibility and environmental conditions. Because these types of surveys can be costly and logistically demanding, inventories will be conducted in representative habitat types through the development of GIS based habitat maps. In order to biologically characterize and ground-truth identified habitats, species presence and distributions will be acquired through field sampling and modeling via accepted habitat classification schemes. Invertebrate species will be included in these surveys due to the pivotal role these organisms play in the marine ecosystem as keystone species and due to management concerns of some commercial and recreational harvestable species, such as clams, sea urchins, and abalone.

Intertidal Inventories

Inventory sites will be selective representations of coastal segments defined primarily by surface substrate and beach slope. Inventories must therefore be conducted as part of comprehensive mapping projects intended to define beach segments along entire park coastlines. Methods for coastal mapping will be adopted from Glacier Bay National Park and Preserve and will greatly aid parks in managing and monitoring their coastal resources (Sharman and Eichenlaub, 2000).

The marine intertidal zone is a dynamic, diverse biological community comprised of algae, invertebrates, and fish. Inventories in the intertidal zone are best conducted through timed area searches, rather than by quadrat or transect sampling. Randomly selected quadrats or transects can miss key microhabitats and can be too time consuming. Timed inventories, however, are advantageous for their simplicity and repeatability. Quadrat and transect sampling are more appropriate for established, long-term monitoring plots, which PORE and GOGA have set up in rocky intertidal areas for natural resource damage assessment.

Species' distributions within the intertidal zone are limited to particular habitats defined by substrate type, degree of wave shock, desiccation, salinity, temperature, and predator distribution. The timed inventory will encompass all these habitats by including the low, mid and high intertidal zones. Care will be made to record species in all microhabitats, including tidepools (especially in the low zone), on and in algae and their holdfasts, in rock crevices and cracks, under rocks, and in sand and mud. These areas can be especially high in species diversity. Species that are difficult to identify in the field will be collected, preserved, and identified in the laboratory. Qualitative abundance or percent cover rankings will be made of keystone, indicator, and harvestable resources such as starfish, mussel beds, abalone, the algae *Fucus gardneri*, sea urchins, and worm and clam siphon holes. Additionally, voucher specimens of all species encountered through the duration of the inventory project will be collected in accordance with NPS standards.

Surveys for intertidal fish are extremely difficult, time consuming, and labor intensive, and consequently, require the initial coastal mapping effort to efficiently select fish survey locations. Fish survey sites will be stratified by habitat type upon completion of a shoreline map and sampled using a combination of minnow traps and beach seines.

Subtidal and Deep Water Inventories

Similar to inventories in the intertidal zone, sub-tidal and deep water marine habitats will be inventoried in conjunction with a GIS habitat mapping project. Habitat classification schemes will be applied to seafloor substrate and bathymetry data collected remotely with side-scan sonar, LIDAR, and/or multi-beam depth sounders (Greene *et al.*, 1995; Greene *et al.*, in press). The CDFG is currently revising their marine classification types and will be ready to employ as needed during this project (Shaffer, 2000). Kelp beds will also be delineated since this non-vascular plant serves as a significant component of the subtidal marine system, with associated fish species. These methods have been employed in the Monterey Bay National Marine Sanctuary, with particular emphasis at the Big Creek Ecological Reserve in Big Sur (Yoklavich *et al.*, 1997), and are serving as a model in the state for inventorying marine habitats. Moss Landing Marine Laboratory and Cal State Monterey Bay both have full survey capabilities and have collaborated with the NPS on several past and current resource projects. Biological surveys are a key component of the habitat mapping project. The surveys will ground-truth GIS products, further classify identified habitat types, and will provide the SFBAN with general inventory data on marine fish and mega-invertebrate species.

Marine fish surveys will be predominately conducted across video transects stratified by habitat type (i.e. marine nearshore exposed coast: kelp forest, marine nearshore embayment: shallow water benthic, etc.) using drop cameras deployed from a vessel, submersibles, and/or remotely operated vehicles (ROV) guided by a pilot from a deployment vessel. In safe shallow waters, divers may be deployed to survey fish transects through direct visual observation. Other commonly used fish sampling techniques include otter trawls, hook and line sampling, and baited traps.

Mega-invertebrates will also be documented using video transects across different habitat types. Additional data may be acquired through core samples in soft sediment types.

Terrestrial Invertebrate Inventories

Prior to the initiation of terrestrial invertebrate inventories, the Inventory Coordinator will review previous inventories, university research and voucher specimens to create a preliminary presence/absence list. The broad sampling necessary for an invertebrate inventory requires a variety of methods. The four sampling methods planned for use in the proposed, but unfunded, terrestrial invertebrate inventory work include pitfall traps, sand screening, pan trapping and sweep netting. All sampling protocols would use either a grid system or transects chosen from a simple random design based on equal-sized segments in the identified band of habitat. Seasonal and annual variation necessitates at least two years of collection. USDA personnel, university graduate students or professors would do the majority of sample identification and it would be done to the genera or species level where possible.

Determining Inventory Completeness

Due to the limited timeframe in which this study plan was developed, current inventory completeness levels within the SFBAN were estimated through expert opinion (Table 7). Future inventory projects outlined in this study plan, however, will employ more rigorous approaches to determine inventory completeness. For some taxonomic groups range maps, wildlife habitat relationship models, and expert opinion will be used to generate a master list of species expected to occur within a given park. The total number of species documented during inventories in the park can then be compared with the total number of species on the 'master list' to determine how complete the inventory is. Alternatively, inventory completeness can be estimated by developing species accumulation curves over sampling time and area, as is being applied to the current avian inventory at PORE and GOGA. The inventory will near the 90% completion level as the species accumulation curve flattens out.

Step 4: Data Analysis and Reporting of Projects

Overview

Inventory project data will be summarized and analyzed through the creation of databases, GIS layers, and annual reporting. Metadata for all I&M databases (tabular and GIS) will be captured in Dataset Catalogue or another Federal Geographic Data Committee (FDGC) (see Step 5: Network Data Management). These products will be made available to the SFBAN parks, the San Francisco Regional Office, the NPS Inventory and Monitoring Program office, outside agencies, and the interested public.

Database Creation and Function

Microsoft Access databases will be developed to archive, summarize, and analyze field inventory and monitoring data. The databases will be designed to make data entry and review easy and efficient. Digital data entry forms will

be modeled after field forms. The front-end of a database should consist of start-up forms and switchboards that move the user between different data entry forms, to pre-designed queries and sorted records, and to print options for pre-designed reports. Quality control measures, such as validation rules, input masks, macro calculations, and data entry limitations to listed values in combo boxes, will facilitate data entry and validation. Actual data entered in the form view is stored in a table or series of related tables. Relationships between these tables will be pre-defined through key fields in order to query linked tables. Measures will be taken to prevent accidental edits to stored data or the database design. Prior to using a database, relevant queries and analysis will be developed, designed, and tested by the project manager or contractor.

Eventually, the data and metadata will be accessible to other resource managers and the interested public from the Network Inventory Coordinator (Section IV).

GIS Development

Field crews will use differential GPS units to record the locations of sampling sites and other relevant spatial data (i.e. nest locations). GIS data will be downloaded, converted to GIS, and displayed on maps for reporting purposes. FDGC metadata will be developed for all GIS data. Linking ArcView projects to MS Access in order to conduct spatial analysis and display plot locations is an alternative to creating GIS themes when geographic coordinates are stored in MS Access. General distribution maps for some species, or species assemblages, may be modeled based on habitat associations (methods for creating these models are addressed in project statements and work plans). Density distribution maps or breeding site maps will be produced for species of significance, such as California red-legged frogs, salt-marsh harvest mice, and rare plants. Professional quality maps will be created for additions to reports and presentations. GIS database development, analysis, reporting and map production will be the responsibility of the project manager or contractor conducting the work. The Inventory Coordinator will assist project mangers with GIS work in cases where the individual park's GIS resources are limited.

Reporting

Annual progress reports of each project will summarize the status of inventories and present preliminary results. Final project reports will display data using tables, graphs, and GIS maps. Inventory project reports should estimate species richness of different taxonomic groups and present species lists by habitat type when possible. Projects assessing the abundance and distribution of species or habitats of concern will give the current status of the resources in question, identify threats to the resources, and present management options if necessary. Reports should additionally address relevance and methods for long-term monitoring, as some of the information collected during the inventory effort may serve as reference data for long-term monitoring. Project reports will be incorporated into annual reports for the entire inventory program for the SFBAN.

Step 5: Network Data Management

Overview

Data management guidelines provided by the NPS I&M program have been developed and are available on the web (http://www.nature.nps.gov/im/dmproto/httoc.htm). The individual project managers, contractors, and the Inventory Coordinator will follow these guidelines. One of the primary responsibilities of the Inventory Coordinator will be to insure that project managers follow good data management practices. Data will be consolidated from each park's inventory into a network data management system. Some parks will be combining inventory efforts and so network based summaries of species will be possible from this central system. All databases, GIS layers, and associated metadata will be stored and archived at this central location. Each park, though, may collect supplementary data during park-specific inventories in order to fulfill specific management needs. For example, the Coho and Steelhead Restoration Project between PORE, GOGA, and MUWO developed a database that is a reservoir for all field data relevant to that project, including spawner surveys, smolt trapping, juvenile snorkel surveys, electrofishing surveys, in stream habitat assessments, and channel morphology. These park specific inventory data will be retained in each park and not at the central location.

Data Storage

Data for the network will be stored on a computer dedicated to the inventory of the network of parks and at each individual park for which the data are associated. These data will be backed up daily. Two backup copies will be created with one being stored offsite. Additionally, copies will be shared annually with the national and regional inventory coordinators.

Database Management

Dataset Catalogue, under development by the National Inventory and Monitoring program, will be used to create and store metadata records for all tabular I&M databases. Dataset Catalogue, or another spatial metadata creation program, will be used to create metadata records for GIS data. Metadata management will be centralized for the SFBAN of parks at one location. NPSpecies, NRBib and the link to ANCS+ will be located at the central data server and updated annually as new information is found through additional data mining and field inventory projects. Additionally, spatial data (ESRI GIS maps and associated databases), protocols, reports and voucher data will be located at the central location.

Reports

Network reports will be produced annually, for four years, to summarize and synthesize the products of the inventory program for the network of parks. These reports will be distributed to each park, to the regional and national offices and placed on the Internet. Reports will include information on specific findings for each park and summarized for the network. All data will have associated metadata records. GIS data will be in an ArcView compatible format. Additionally, annual summaries of NPSpecies, NRBib, and ANCS+ databases will be presented.

SECTION IV: ORGANIZATIONAL STRUCTURE

Overview

The organizational structure of the SFBAN I&M Program is contingent upon 1) the role of the steering committee, and 2) the role of the Inventory Coordinator.

Steering Committee

A steering committee will guide the inventory program for the SFBAN parks. The steering committee will be responsible for deciding funding allocation, contracting, and prioritization needs. The committee will be composed of one person from each of the parks and the Inventory Coordinator. A rotating committee member from one of the parks will serve as the chair of the committee. The current committee composition is presented in Table 11. Representatives of the USGS-WERC, including Marsha Irving-Seminoff and Dr. Judd Howell at GOGA, will provide additional consultation. Other members may be added from other agencies, such as the National Marine Sanctuaries, as appropriate.

Table 11. List of current I&M steering committee members

Name	Position	Park
Sarah Allen	Science Advisor	PORE
Gary Fellers	Research Biologist	USGS-WERC (PORE)
Amy Fesnock	Wildlife Biologist	PINN
Glenn Fuller	Superintendent	EUON
Daphne Hatch	Wildlife Biologist	GOGA
Barbara Moritsch	Botanist	PORE
Phyllis Shaw	Superintendent	JOMU

Inventory Coordinator

An Inventory Coordinator will be hired to provide efficiency and synthesis of the SFBAN inventory. This coordinator will have several duties including 1) data mining, 2) data management, 3) administrative project oversight, and 4) budget administration.

Inventory workshop participants identified data mining as a primary action item because there is a wealth of data known to exist in the region, but is not necessarily reflected in current updates of NPSpecies and NRBib. The coordinator would continue to compile collection databases from identified sources and to search smaller, "unofficial" collections (private holdings, for example). In addition, the coordinator will seek assistance from the I&M Program office in conducting searches for specimens in larger regional and national museums. Since many of these institutions have restrictions on the access and use of their collections, a larger-scale, unified approach may simplify this process. The coordinator will also work with NPS collection managers in each of the Network parks to address the issue of uncataloged specimen collections and to define an approach to updating ANCS+. All existing specimen datasets will be incorporated into NPSpecies after review by park staff. Since many vouchers were

collected before the parks were officially established, collection locations must be reviewed to insure that specimens were, in fact, collected within current park boundaries.

The coordinator will also assume responsibility for administration of projects and the annual I&M budget for the network of parks. Coordination of logistical support and personnel will insure effective communication and efficiency within the network. Finally, the inventory coordinator will be responsible for managing project inventory data and project GIS layers and associated metadata in a central data management system (Section III: Project Description, Step 5: Network Data Management).

Facilities

The Pacific Coast Learning Center located in PORE will function as a facility to assist in coordinating the inventory efforts. This Center is one of the first four Learning Centers established in the country by the NPS where scientists and educators can study in parks. The Center will provide housing, computer facilities, and laboratory space for visiting scientists and students. The Center is centrally located to service the field needs of scientists working in GOGA and PORE.

SECTION V: BUDGET AND SCHEDULE

The budget for the inventory of the SFBAN parks involves 18 projects that have been, or will be, funded over five years (2000-2004). The total estimated cost is $682,333 (Table 12, Appendix C). Some of the projects are only partially funded because other sources of funds have been identified for sharing the costs. The number one priority identified by the network of parks was hiring an Inventory Coordinator to continue collection of existing data. The parks recognize that significant amounts of data exist that have yet to be compiled. After this step is completed, then a strategic plan for remaining field inventories can be more precisely targeted. This is particularly true for marine fish, marine invertebrates, and vascular plant inventories. Much of the budget focuses on the needs of JOMU, EUON, and the new lands of PINN. Marine invertebrate and non-vascular plant species are targeted in two of the projects because these species are fundamental to function of the marine ecosystems of GOGA and PORE. These two projects are also only partially funded because of partnerships with other agencies, including the National Marine Sanctuaries, UC Bodega Marine Lab and the California Department of Fish and Game. A breakdown by park of costs and projects is presented in Appendix C. The requested annual amount of funding is around $150,000 per year for five years.

SECTION VI: RESUMES

The resumes of three principal investigators are presented in Appendix F.

Table 12. Budget and schedule of I&M Program funds allocated to the SFBAN. Accounts for money spent in 2000 and outlines proposed budget and schedule in 2001–2004, as detailed in Appendix B.

Item	Park	Cost	2000	2001	2002	2003	2004
Data Inventory	ALL	$38,002	$36,002				
Inventory Workshop	ALL	$3,107	$3,107				
Technical Supplies (i.e., computers)	ALL	$9,799	$9,799				
Vegetation Mapping	PORE, GOGA, PINN	$23,407	$23,407				
Multi-Species Inventory	PORE, GOGA	$48,926	$48,926				
Herbarium Assessment	ALL	$26,759	$26,759				
Inventory Coordinator	ALL	$130,000		$52,000	$52,000	$26,000	
Vegetation Inventory	JOMU, EUON	$40,000		$40,000			
Vascular Plant Inventory of New Lands	PINN	$55,000			$27,500	$27,500	
Rare Plant Inventory	PORE, GOGA	$55,438		$9,600	$18,119	$13,859	$13,860
Salt Marsh Harvest and Point Reyes Jumping Mouse	PORE, GOGA	$25,000					$25,000
Bat Inventory	ALL	$30,250				$30,250	
Small Mammals and Herpetofauna Inventory	PINN	$25,230				$25,230	
Small Mammals and Herpetofauna Inventory	JOMU, EUON	$8,765		$8,765			
Riparian Aquatic Species Inventory	PINN	$68,500		$34,250	$34,250		
Coastal Biological Resources Inventory	PORE, GOGA	$55,000					$55,000
Sub-tidal and Deep Water Inventory	PORE, GOGA	$25,000				$25,000	
Bird Inventory	PINN, JOMU, EUON	$14,150		$14,150			
TOTAL		$682,333	$150,000	$158,765	$131,869	$147,839	$93,860

SECTION VII: REFERENCES

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